Policy: 8085-2- GPS Data Collection Policy
Section: Geospatial Standards
Office/Department: Office of IT Application Support & Development

Reports To: Information Technology
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Purpose

The goal of this publication is to provide a means of quality control and accuracy documentation of Geographic Information System (GIS) or geospatial data sets created with Global Positioning System (GPS) technology.

These GPS data collection guidelines seek to accomplish the following objectives:

1. Establish methodology for collecting GPS data for use in a GIS;
2. Provide guidelines for reporting metadata about GPS collected data and methods/means used to collect such data;
3. Supply GPS users with definitions of GPS terms and abbreviations; and
4. Eliminate or reduce known and potential systematic errors.

Licensed Land Surveyors commonly use Survey Grade GPS when performing boundary and topographic surveys which this publication will not address.

GPS signals are subject to the several sources of error. The items in this publication are designed to mitigate the following errors:

- Multipathing
- Atmospheric, tropospheric, or ionspheric interference
- GPS receiver settings
- Field collection errors
- Data processing errors
- Quality control errors
- Data delivery issues

Definitions

Geographic Information System (GIS)	An information system to edit, store, analyze, or share geospatial data.
Geographic Positioning System (GPS)	GPS consists of a constellation of a minimum of 24 operational satellites that orbit the earth and maintained by the U.S. Department of Defense. These satellites broadcast radio signals, containing satellite position and precise time data, twenty-four hours a day. GPS receivers use these signals to determine a geographic location.
Geospatial	Of or relating to objects on the Earth's surface. Commonly used to refer to GPS or GIS.

Metadata	Data about data o information that describes the characteristics of the GIS data set.
Real Time Differential Correction or Differential GPS (DGPS)	FM beacons managed by the US Coast Guard, US Geological Survey or WAAS that broadcast corrections.
Real Time Kinematic (RTK)	A real-time differential GPS method that uses carrier phase measurements for greater accuracy. RTK measurements typically yield relative horizontal accuracy of approximately one centimeter.
Satellite Based Augmentation System (SBAS)	The generic term that refers to differential GPS applied to a wide area, such as an entire continent. WAAS and EGNOS are examples of SBAS networks, and are comprised of a series of reference stations that generate GPS corrections which are broadcast to GPS rovers via geostationary satellites.
Wide Area Augmentation System (WAAS)	WAAS was established by the Federal Aviation Administration (FAA) for flight and approach navigation for civil aviation. WAAS improves the accuracy and availability of the basic GPS signals over its coverage area, which includes the continental United States and outlying parts of Canada and Mexico. The WAAS system provides correction data for visible satellites. Corrections are computed from ground station observations and then uploaded to two geostationary satellites. This data is then broadcast on the L1 frequency, and is tracked using a channel on the GPS receiver, exactly like a GPS satellite.
World Geodetic System (WGS-84)	The mathematical ellipsoid used by GPS since 1984.

Categories of GPS Receivers

The Georgia DOT uses a variety of GPS receivers to achieve data accuracy requirements of the feature being collected.

Smartphones can achieve real time horizontal accuracies within 3 - 20 meters (m). Smartphones typically use wireless networks and cellular triangulation to aid in improving positional accuracy. However, cellphones typically lack the capabilities to validate data accuracy requirements. These devices typically do not natively support settings for data quality control or post processing. Use of these devices for GPS collection shall require review and approval by the Georgia DOT IT Enterprise GIS Team.

Recreational grade receivers achieve real time horizontal accuracies within 5 - 20 m. These GPS receivers usually do not have the ability to "post-process" collected data, but may have the ability to perform real time correction using Wide Area Augmentation System (WAAS). These GPS receivers can be used to navigate to a specific area and/or compile uncorrected GPS data (~ within 10 m). Recreational grade receivers are used for general navigation and feature identification. They are usually not suitable for roadway inventory, asset management, or similar Georgia DOT collection data collection efforts.

Mapping grade receivers achieve real time horizontal accuracies of sub-meter to 5m. These GPS receivers have the ability to log raw GPS data, enabling these GPS-collected data to be post-processed utilizing desktop GPS software and allowing locations to be refined or corrected to a higher level of precision than inherent in the raw data. This category of GPS receiver also has the ability to communicate with a base station, store attributes of features, use a data dictionary and upload data from the GPS device to a PC. This system may also have features to connect to WAAS and Differential

GPS (DGPS) positions broadcast by the federal government or commercial services (terrestrial or satellite beacons). Mapping grade receivers are used by the Georgia DOT for road inventory, asset management, and environmental assessment.

Utility grade receivers achieve real time horizontal accuracies of 10 centimeters (cm) to 1 m. These GPS receivers also include the capabilities of recreational and mapping grade receivers. These devices are typically used for pipes, poles, manholes, or other design structures where one must distinguish features within a meter.

Survey grade receivers include instruments with associated software that can achieve one centimeter relative accuracy. These are used by land surveyors primarily for boundary, topographic, and geodetic surveys, photogrammetry, and other activities requiring high accuracy. Specialized training is needed to use this equipment. These devices have the capability to accept Real-Time Kinematic (RTK) signals. **These devices are not addressed within this document and users should refer to surveying/design standards for this specific information.**

Data Collection Methodology

Contractor/Consultant Selection

- Contractors/consultants performing the GPS data collection and GIS processing shall be evaluated:
    - On the level of the training and knowledge of their staff in the proper use of equipment, collection practices, data processing, metadata preparation, and software to meet Georgia DOT requirements.
    - On their quality control and quality assurance procedures.
    - On their experience and capabilities in best practices collection of the features specified.
- The prime contractor/consultant bears full responsibility for the quality of deliverables sent to the Georgia DOT.
- Task Orders and Statements of Work or any other type of contract vehicle used by GDOT shall specify data accuracy requirements for feature collection.

Pre-collection Requirements

- Georgia DOT business units shall provide any collection specific guidance on the feature being measured.
- Georgia DOT business units shall define if the data will be maintained internally or externally.
- If maintained internally, the database schema will be developed in conjunction with the Georgia DOT IT Enterprise GIS Team Leader, and the design must be approved by either the Administrator or one of the Assistant Administrators of GDOT's IT Application Support & Development Office prior to development commencing.
- The Georgia DOT shall review and approve the Data Dictionary to be used for field data collection. The data dictionary shall contain constraints to prevent field collection data entry errors.
- File naming conventions, file formats, compression, media, and organization of files on the media for delivery shall be approved by either the Administrator or one of the Assistant Administrators of GDOT's IT Application Support & Development Office prior to collection.

Mission Planning

- GPS satellite almanacs shall be downloaded and updated prior to collection or at least monthly.
- Satellite availability at collection site shall be assessed for optimum collection times and collection efficiency.
- Select base or reference stations between 30-60 miles of data collection site. Validate the quality of the base station and use only Continuously Operating Reference Stations (CORS), National Oceanic and Atmospheric Administration (NOAA) reference stations, or National Geodetic Survey (NGS) published base stations.

- If DGPS is used, stations shall be within 150 miles of the collection site.
- Commercial satellite (e.g. OmniSTAR) or terrestrial differential correction services (e.g. eGPS) may be used to meet accuracy requirements.

GPS Device Specifications

Below is a minimum GPS device specification for data collection for GDOT.

Number of Channels	Receivers shall have at least 12 channels to receive GPS signals
Dual-frequency	Receivers shall be capable of receiving L1 and L2 signals form GPS satellites.
Integrated SBAS receive	Ability to receive SBAS signals.
Time to first fix	30 seconds

GPS Receiver Settings

Devices shall be selected for achieving the accuracy requirements of the project. The following minimum values shall be set on the GPS receiver prior to field data collection. The values below may be modified as per Task Orders and Statements of Work depending on the requirements of the project. Additionally, the user should consult the manufacturers' guidelines for optimal GPS receiver configuration recommendations.

Number of Satellites	At a minimum, **4 satellites** shall be required for every position.
Positional Dilution of Precision (PDOP) Values	The GPS receiver shall be set to collect data at a PDOP value of **6 or less**. PDOP values higher than 6 result in reduced accuracy. Start collection with a PDOP of 4 and shift up to 6 if data collection is unsuccessful. Vertical Dilution of Precision (VDOP) and Horizontal Dilution of Precision (HDOP) should also be set to achieve PDOP values.
Signal to Noise Ratio (SNR) Mask	Set the value of the SNR mask at **a minimum of 6**. This setting varies by GPS receiver manufacturer. Higher signal quality is desired to improve data quality.
Elevation Mask	The elevation mask shall be set to collect **at a minimum of 15 degrees**.
Data Collection Rate	Point data shall be collected at a **1-second interval**. Polygon and line data shall be collected w**alking at a 5-second interval and driving at 1-second intervals**.
Mode	**3D positions** shall be captured.
Altitude Reference	**Height Above Ellipsoid (HAE)**
Datum	The datum of collection will be **WGS-84, NAD-83, GRS80** or a datum that better meets the project accuracy requirements.
Projection	Data shall be collected in the unprojected geographic coordinate system latitude/longitude. Data reprojection shall be done during data processing into GIS data.
Coordinate and Altitude Units	Set to **meters**.
Units of measure	Data shall be collected as **Decimal Degrees (DD)**.
Data Precision	Data precision shall be greater than or equal to the accuracy requirements. **The minimum value of digits beyond the decimal place is 5 digits**. Length or precision will be 18, scale will be 15, and zeros will be used to carry out the value to the 15th place beyond the decimal point if not measured.
Time of Collection	Data shall be collected for stationary features at **a minimum of 30**

	seconds. More positions are desired to improve data quality.
Record Stamping	Each record shall be stamped with the positional accuracy information (PDOP), receiver type, total positions, mask level, identification of the collector, date/time stamps, and any offset information to isolate quality control issues.

Elevation Data

If elevation data is required by the project, it will be referenced to the North American Vertical Datum of 1988 (NAVD 88) vertical geodetic datum. Elevations must be generated as orthometric heights (relative to mean sea level) determined using the GOID03 (CONUS) or later geoid conversion model.

GPS Collection

- GPS devices shall be positioned to maintain a line of sight skyward free of obstructions and mitigating multi-pathing errors.
- In collecting features, approach or stand to the south side of the feature to improve elevation angles.
- Field data collectors shall be prohibited from editing the Data Dictionary.
- If the device is equipped with a camera, all photographs referenced to the feature shall be geotagged in the Exchangeable image file format (EXIF) header with WGS84 NAD 83 latitude/longitude coordinates.

GPS Data Downloading and Processing

- Download all GPS data to a computer after returning from the field.
- Post-process or differentially correct data to achieve the highest accuracy possible and as soon as possible to obtain reference station measurements.
- Use the same base stations across the data for consistency.
- Use base stations within 60 miles of the collection site. Use one base station for small collection areas. Split up large areas into smaller areas to use the same base station for data homogeneity.
- The data downloading and processing varies by GPS receiver manufacturer. Follow GPS receiver user manuals for data creation.
- Raw data files shall be stored and retained for the duration of the collection period to deliverable acceptance in order to restore or redo data processing.

Data Quality Control

- Data collected within the State of Georgia shall have a spatial extent within the State of Georgia.
- Data outliers shall be removed and recollected prior to data delivery.
- 95% of the positions fixes shall be within the accuracy requirement for the feature.
- Remove uncorrected positions and positions not conforming to the GPS Receiver Settings.
- Spot-checking and analysis of records shall be performed to validate data accuracy requirements are satisfied.
- High resolution aerial photography, satellite imagery, or GIS data of known accuracy shall be used for visual assessments to identify data outliers for removal.
- Positions shall meet the accuracy requirements stated above. Any submittals that do not meet the accuracy requirements stated above will be discarded.

- Attribute data shall be checked for inconsistencies or inaccuracies.
- GPS device accuracy shall be validated against a known High Accuracy Reference Network (HARN) or High Precision Geodetic Network (HPGN) NAD83/(94)or NAD83/(2007)monument at least quarterly own when data is questionable to confirm operational integrity of the device. Repair or dispose of faulty receivers.

Geospatial Deliverables

- A listing of the GPS base stations used for the project shall be provided upon Georgia DOT request.
- All geospatial metadata shall state the make and model of the GPS device, methods of post-processing, and processing software. The metadata shall also note parameters of antennae or offsets used for collection.
- All geospatial metadata shall comply with GDOT Publication 8075-7 – Metadata Registry.
- Delivery of copies of the following used for the project upon Georgia DOT request:
    - Results of GPS device accuracy validation
    - All field notes
    - GPS post-processing logs
    - Uncorrected and corrected GPS files
    - GPS Data Dictionary files
    - GPS to GIS export files
    - Edited and unedited GIS files
- An Information System Security Assessment (ISSA) shall be completed prior to delivery that defines any limitations on access control, use, distribution, and retention of collected/processed data.

References:

- http://gis.ny.gov/coordinationprogram/workgroups/wg_1/related/standards/documents/GPS_Guidelines_FINAL.pdf
- http://www.ncgicc.com/Portals/3/documents/gps-standard-final.pdf
- http://www.state.nj.us/dep/gis/GPSStandards_2011.pdf

History:

Initial Policy
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